REMARKS

I- SUMMARY OF OFFICE ACTION

The Examiner raised an objection that the subject matter of claims 16 and 19 was not shown in the figures.

Claims 1-27 stand rejected under 35 USC 112

Claim 1 stands rejected under 35 USC 103(a) on the basis of Fredriksson et al in view of Smalser.

Claims 14, 23 and 24 also stand rejected under 35 USC 103(a) on the basis of Fredriksson et al and Smalser in view of Yamamoto.

Claims 13, 15-17, 19, 20 and 25 also stand rejected under 35 USC 103(a) on the basis of Fredriksson et al and Smalser in view of Yamamoto and in view of Muljadi.

Claims 2-12, 18, 22, 26 and 27 were indicated to be allowable if rewritten to overcome the formal objection and to include all limitations of the base claim and any intervening claims.

II- RESPONSE TO ISSUES RAISED IN THE OFFICE ACTION

Before discussing the claims in detail and the Examiner's objections, it should be noted that Applicants' invention resides, in part, in the recognition of the following:

1- In a wave energy converter (WEC) which includes mechanical components responsive to motion of the waves (their amplitude and period) and where the mechanical components are arranged to drive an electric generator producing an output at which is produced a voltage and/or a current in response to the

motion of the waves, the optimum load (which may be expressed as an impedance or a resistance) to be connected across the output of the electric generator, to obtain maximum power transfer, is made to have a value which is a function of the period of the waves (I.e., to be a function of the frequency of the driving force represented by the waves).

2- Where the WEC includes a shell (e.g., a cylinder) mounted about a piston, the optimum load to be connected across the electric generator output is made to have a value which is a function of the period of the waves **and** the mass of the WEC including the water column in the shell.

3- For purpose of calculating and selecting the value of the optimum load to connect to the system in order to derive the maximum power transfer, Applicants recognized that the mass of the WEC including the water column and the mechanical-to-electrical converter may, for example, be characterized as an equivalent electrical component which, dependent on the operation of the WEC functions as effective capacitance or an inductance.

4- **A significant aspect of the invention is the further recognition that the optimum power transfer condition occurs when the load is made to resonate with the system supplying power to the load.** That is, the load is selected to

have a value (and characteristics) such that when it is connected to the output of the electric generator, the entire system including the WEC is operated at resonance (or as close thereto as is feasible). This condition may be achieved, for example, when the load has a value which is a function of $1/(\omega)(C_E)$; with ω and $\mathbf{C_E}$ being the elements defined in the specification.

The claims are intended to capture the invention(s) described above.

DISCUSSION OF FORMAL OBJECTIONS RAISED BY THE EXAMINER:

In para. 1 of the office action the Examiner requires that: the "reactive component coupled to the output of the electric generator in series with the load as disclosed in claim 19 must be shown..". It is submitted that this is already shown in Figs. 5, 5A, 7, 8, 9, 9A, and 10. By way of example, in Fig. 10 the claimed subject matter corresponds to elements 42a, 510 and 60; where 42a designated as the mechanical force to electrical energy converter includes an electric generator, element 510 which is designated as capacitive and as a resonating network is a reactive component for resonating with element 42a and element 60 is the load. The output of element 42a (which may correspond to the output of the electric generator) may appear to be inductive LEFF; in which case the reactive component 510 coupled to the output of element 42a is capacitive CEFF .

To avoid an element of confusion it should be noted that, as is known from basic electronics, the reactance XL of an inductive component (L) may be expressed as XL= ωL and the reactance Xc of a capacitive component (C) may be expressed as Xc = 1/ωC.

Claim 19 calls for the output of the electric generator to exhibit either an inductive reactance or a capacitive reactance and for a reactive component to be coupled to the output of the electrical generator to exhibit a reactance complementary to that exhibited by the electrical generator. This is repeatedly shown in the figures and discussed in the specification.

With respect to claim 16 it is submitted that Fig. 9A shows controller 54 coupled to (a) component 60a which supplies a regulated AC load; and (b) component 60b which is in turn connected to component 60c which supplies an AC load. In Fig. 9A element 500 is shown to be an inductor. Components 60a, 60b , 60c include capacitive elements as do the AC loads being supplied. The controller 54 provides switchable interconnection for to selectively increase or decrease the capacitance in the power loop.

Note that Fig. 5A likewise shows controller 54 coupled to components 50a and 50b to accomplish the function described in claim 16.

Pending the Examiner's review of these comments claim 16 is being kept in its original condition.

With respect to the "formal" objections raised in Paragraphs 2 and 3 of the office action, it should be noted that claim 1 has been amended to specify that the load has an "impedance whose value is selected to be a **function** of the

period of the waves in said body of water and of the mass of water in the shell." This is a general statement of the more exact relationship recited in claim 2.

Claim 2 has been amended to state that the impedance of the load is <u>selected to be</u> approximately equal to 1/ (ω)(C_E)for optimizing the <u>electric</u> generator power output; where:

ω is equal to the angular frequency of the waves <u>in said body of water</u> expressible as $2\pi/T$ where T is the period of the waves; and

C_E is approximately equal to MT/K , where MT is approximately equal to the mass of the shell and the mass of the water moved by the shell, and K is an electromechanical coupling constant.

The relationship and derivation of the optimum load resistance is set forth at pages 9 and 10 of the specification and is explicitly described in eq. 7 (page 10). The "impedance" referred to in claims 1 and 2 corresponds to R_L shown in Eq. 7 and to the value of R_L. However, the claims recite the load **more broadly in terms of an impedance.**

With respect to additional questions raised in paragraph 3 of the office action it should be appreciated that the system is designed to operate within a certain range. That is, the average wave amplitude and wave period in a certain area where the WEC is placed are known. As discussed in the specification the system may be designed to operate within a range represented by the average values. Alternatively, wave sensors may be used to control the controller to vary the load and the operation of the system as a function of variations in the amplitude and period of the waves. Where the amplitude of the

waves exceed certain values, generating excessive forces, the system would include safety features limiting the response of the system.

Regarding the value of the electromechanical constant K which is expressed as being equal to $K_G K_T / r_o^2$, where K_G, K_T, and r_o are defined in page 7 of the specification. By way of example, for a structure such as the WEC shown in Figs 2 and 2A, the WEC includes a shell and piston coupled to a hydraulic motor. In response to the relative motion between the shell and the piston, the hydraulic motor has an output shaft which rotates. The term "r_o" represents the angular velocity of the hydraulic motor shaft resulting from the linear motion (e.g., up down) of the WEC. The shaft of the hydraulic motor is coupled to the shaft of an electric generator and causes the electric generator to rotate. The terms K_G and K_T are constants which pertain to characteristics of the electric generator (EG) and are a function of its construction and are obtainable from the manufacturer of the electric generator. Thus, K_G indicates the voltage produced at the output of the EG when the shaft of the EG is turned at a certain rate and K_T indicates the torque developed by the EG as a function of the current drawn by the load. It is submitted that this is known to those skilled in the electric motor/generator art.

The movement at a velocity (v) of the shell/piston causes the shaft of the hydraulic motor (HM) to rotate at an angular velocity proportional to v/r_o. The corresponding output voltage (OV) developed at the output of the EG (coupled to and driven by the HM) may be expressed as $(v/r_o)(K_G)$. The output current (I) available from the EG for a given load R may be expressed as $(v/r_o)(K_G)/R$.

The torque on the EG may be expressed as T= (I)(K_T). The power available from the generator may be expressed as the torque(T) times the angular velocity (v). Substituting from the above this yields an expression for power developed by the EG which is a function of $K_G K_T/r_o^2$. If the Examiner requires additional explanation he is invited to contact Applicants' attorney.

With respect to questions raised in para. 5 of the office action----

(a) The impedance of the load is selected to have a value which is a function of the **period of** the waves where the WEC is located and of the mass of the water in the shell. As discussed above and in the specification, the value of the load may be fixed or it may be varied by means of a controller responsive to various inputs.

(b) In claim 19, as discussed above, a reactive component is either an inductor or a capacitor. If looking into the output of the electrical generator the equivalent is capacitive then an inductor will be coupled to the output of the electrical generator to provide inductive reactance . On the other hand, if looking into the output of the electrical generator the equivalent is inductive then a capacitor will be coupled to the output of the electrical generator to provide capacitive reactance.

(c) Claims 20 and 25 employ a similar terminology to claim 19 and should be similarly construed.

With respect to the rejection of claim 1 under 35 USC 103(a)---- claim 1 has been amended to emphasize that the load has a value which is selected to be a function of the period of the waves in the body of water in which the WEC is located and of the mass of the water in the shell of the WEC. This is not shown taught or suggested in Fredriksson et al and Smalser. In so far as it is understood, Fredriksson et al shows a certain type of WEC. There is no teaching pertaining to the nature of the load impedance. As for Smalser, the teaching is to vary the load connected to the electric generator in such a manner as to render the electric generator more efficient; not the entire system.. There is no teaching or suggestion in the cited references pertaining to setting the value of the load based on the period of the waves and the mass of the system. In contrast to the prior art, Applicants' recognized that the impedance of the load should be made to have a value which is a function of the movement of the waves and the mass of the WEC. Accordingly, claim 1, as amended, is believed to define patentably over the cited references.

Claim 2, dependent form claim 1, was indicated to be allowable if rewritten. Claim 2 has been amended to emphasize that the impedance of the load is selected to be approximately equal to $1/(\omega)(C_E)$ for optimizing the electric generator power output for predetermined conditions of the body of water in which the WEC is placed. This relationship is not shown, taught or suggested in the references and claim 2, as amended, is believed to be correct in formal respects and to define patentably over the references .

Claims 3- 12 dependent directly or indirectly from claim 2 are submitted to be patentable for at least the same reasons as claim 2.

Claim 13 has been amended to emphasize that the system includes a sensor for sensing selected conditions of the waves and a controller coupled to the load for controlling the effective impedance of the load as a function of variations in the waves. It is submitted that this is not shown taught or suggested in the cited references including Fredriksson et al, Smalser, Yamamoto, and Muljadi. Accordingly claim 13, as amended, is submitted to be correct in formal respects and to be patentable over the cited references.

The rejection of claim 14 on the basis of Fredriksson et al, Smalser, and Yamamoto is respectfully traversed. Claim 14 has been amended to recite the condition that the electrical generating portion of the WEC exhibits **inductive characteristics** and the means coupling the load to the output of the electric generator includes a capacitive element **for enhancing a resonant condition** in a series loop including the electric generation portion of the WEC, the load and the capacitive element. There is no suggestion in the combination of the cited references to couple the load to a power generating source via a capacitive element **for enhancing a resonant condition.** Accordingly, claim 14, as amended, is believed to be correct in formal respects and to define patentably over the cited references.

Claim 15 calls for a controller for varying the capacitive element (of claim 14) for maintaining the **system in resonance** as a function of selected characteristics of the waves. In so far as understood, there is no suggestion in

the combination of the cited references for any such structure to perform such function. Accordingly, claim 15 is believed to be correct in formal respects and to define patentably over the cited references.

Claim 16 discussed above is likewise believed to be be correct in formal respects and to define patentably over the cited references.

Claim 17 calls for a sensor for sensing the peak conditions of the waves and a controller responsive to signals from the sensor for varying the load or the capacitive element for maintaining an optimum value of the load and **enhancing resonance of the system**. The recited structure is not shown in the cited references and the concept of enhancing resonance of the system is not shown taught or suggested. Accordingly, claim 17 is believed to be correct in formal respects and to define patentably over the cited references.

Claim 18 dependent from claim 6 is believed to be correct in formal respects and to define patentably over the cited references.

Claim 19 has been amended in formal respects to define that the reactive component coupled to the output of the electric generator is selected to be capacitive if the output of the generator appears to be inductive and is selected to be inductive if the output of the generator appears to be capacitive. In so far as understood, there is no suggestion in the combination of the cited references for any such structure to perform such function. Accordingly, claim 19, as amended, is believed to be correct in formal respects and to define patentably over the cited references.

Claim 20 has been amended in formal respects, in a similar fashion as claim 19. Accordingly, claim 20, as amended, is believed to be correct in formal respects and to define patentably over the cited references.

Claim 21 has been amended in an effort to overcome the Examiner's objection under 35 USC 112. Accordingly, claim 21, as amended, is believed to be correct in formal respects and to define patentably over the cited references.

Claim 22 is now believed to be patentable for its own reasons as well as those adduced for claim 21.

The rejection of claim 23 on the basis of Fredriksson et al, Smalser, and Yamamoto is respectfully traversed. Claim 23 calls for (a) setting the initial value of said load to have an impedance whose value is a predetermined function of the average period of the waves and of the mass of the water in the WEC; and (b) means for varying the impedance of the load as a function of changes in at least one of the frequency, amplitude and phase of the waves providing the input power to the WEC system for maintaining the impedance of the load at a predetermined optimum value. Insofar as they are understood, the cited references do not teach the structure and function recited in clause (a) and (b) above. Accordingly, claim 23 is believed to be correct in formal respects and to define patentably over the cited references.

Claim 24 is submitted to be patentable for its own reasons as well as those adduced for claim 23 from which it depends.

Claim 25 has been amended to specify that the reactive means (which could be an inductive or a capacitive element) coupled between the output of the electric generator and the load is selected to have a value to cause the output of the electric generator and the load coupled thereto to **resonate** with the mass (M_T) of the WEC being moved. For the reasons discussed above this is not shown taught or suggested in the references. Accordingly, claim 25, as amended, is believed to be correct in formal respects and to define patentably over the cited references.

Claims 26 and 27 indicated to be allowable if rewritten are now also believed to be correct in formal respects.

In conclusion, the allowance of claims 1and 2, as amended, claims 3-12, claims 13 and 14, as amended, claims 15-18, claims 19-21, as amended, claims 22-24, claim 25, as amended, and claims 26 and 27 is respectfully requested.

Respectfully submitted

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